2.6W Mono Class-D Audio Amplifier

Features

- Supply Voltage Range: 2.5~5.5V
- High Efficiency up to 90%
- Low Power consumption
  - Shutdown Current: 1uA
  - Quiescent Current: 3mA
- High Audio Performance
  - Maximum THD+N: 0.01%
  - Maximum Output Power: 2.6W
- Low-EMI: Unique PWM Control Method
- Resistive Gain Control : 6dB~24dB
- Short & Thermal Protection
- "Pop and Click" Noise Suppression
- Pb-Free Packages are Available

Descriptions

The CPA011M is a high efficiency filter-free class-D audio power amplifier of delivering 2.6W of continuous average power to a 4Ω from a 5.5V supply in a Bridge Tied Load (BTL) configuration. Under same conditions, the amplifier can provide 1.4W to an 8Ω BTL load with less than 1% THD+N. For portable applications it offers space and cost savings because no output filter is required when using inductive speakers. With more than 90% efficiency and very low shutdown current, it increases the life time of your battery.

The CPA011M processes analog inputs with the unique pulse-width modulation method that lowers output noise and EMI. The gain can be reduced by external input resistors. The CPA011M provides thermal and short circuit protection.

Applications

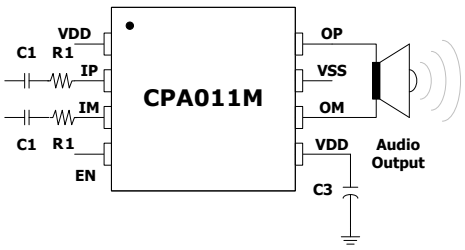
- Cellular Phones
- MP3 Players
- PDAs and Smart Phones
- Portable Audio

Package Info.

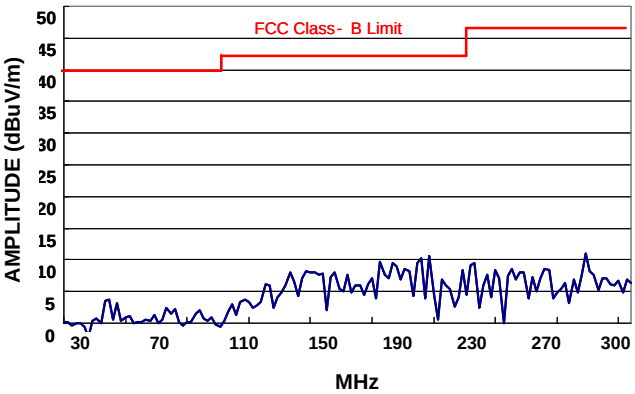
- 8 DFN 2x2 mm available

(The smallest molded package in the world)

Application Circuit



EMI Spread Spectrum



Absolute Maximum Ratings

Over operating free-air temperature range unless otherwise noted

Symbol	Rating	Max	Unit
VDD	Supply Voltage	6	V
IP/IM	Input Voltage	-0.3 to VDD+0.3	V
T_A	Operating free-air temperature range	-40 to 85	°C
T_J	Operating junction temperature range	-40 to 150	°C
Tstg	Storage temperature range	-65 to 85	°C
	ESD Protection Human Body Model (HBM) (Note 1) Machine Model (MM) (Note2) Charged Device Model(CDM)	 >2000 >200 >500	V

Stresses exceeding those listed under absolute maximum ratings may cause permanent damage to device.

1. Human Body Model: 100pF discharged through a 1.5k resistor following specification JESD22/A114.
2. Machine Model: 200pF discharged through all pins following specification JESD22/A115.

Recommended Operating Conditions

Symbol	Rating	MIN	MAX	Unit
VDD	Supply Voltage	2.5	5.5	V
VIH	Low-level input Voltage (EN)	1.3	VDD	V
VIL	Low-level input Voltage (EN)	0	0.3	V
VIC	Common mode input voltage	0.5	VDD-0.8	V
T_A	Operating free-air temperature range	-40	85	°C

Electrical Characteristics

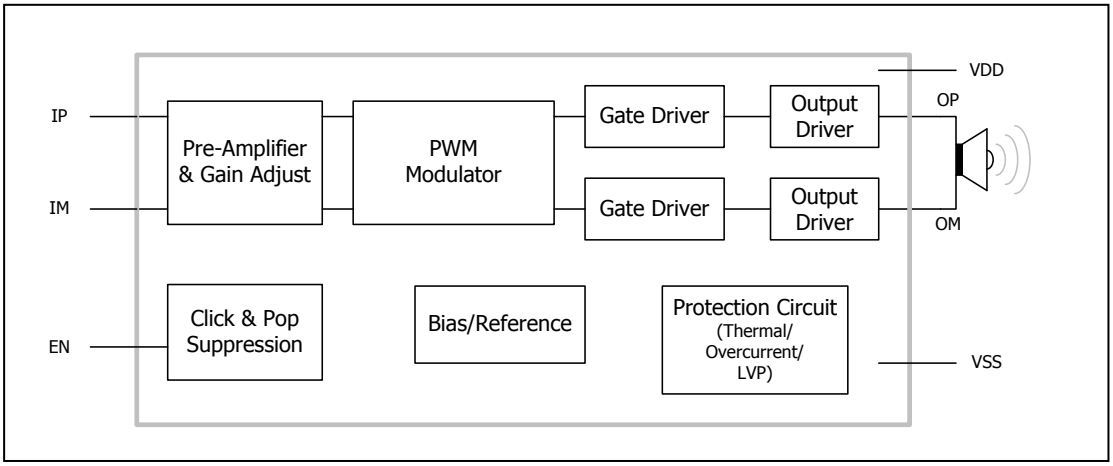
Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Operating Supply Voltage	VDD	T_A=-40 °C to +85 °C	2.5		5.5	V
Supply Quiescent Current	I_Q	VDD=5.5V, No load VDD=3.6V,No load VDD=2.5V,No load		3.3 2.6 2.3	5 3.5 3	mA
Shutdown Current	I_{SD}	VDD=2.5V to 5.5V		1	5	μA
Switching Frequency	F_{SW}	No input	330	380	480	kHz
Output offset Voltage	$\|V_{OC}\|$	Inputs ac grounded, A_V=6dB			25	mV
Power Supply Rejection Ratio	PSRR	VDD=2.5 to 5.5V			-75	dB
Common-mode Rejection Ratio	CMRR	Inputs shorted together VDD=2.5 to 5.5V			-60	dB

Operating Characteristics

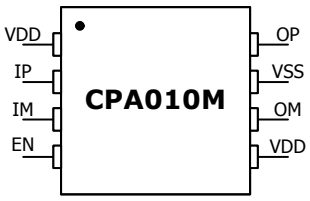
Parameter	Symbol	Conditions		TYP	MAX	Unit
Output power	P_{OUT}	Load=4Ω+22uH, Fin=1kHz, THD+N=1% (Note.1)	VDD=2.5	0.5		W
			VDD=3.6	1.1		
			VDD=5.5	2.6		
		Load=8Ω+22uH, Fin=1kHz, THD+N=1%	VDD=2.5	0.3		
			VDD=3.6	0.7		
			VDD=5.5	1.6		
Total harmonic distortion plus noise	THD+N	VDD=5.5V, Fin=1kHz, Load=8Ω, P_{OUT}=0.5W		0.02	0.1	%
		VDD=3.6V, Fin=1kHz, Load=8Ω, P_{OUT}=0.3W		0.02	0.1	
		VDD=2.5V, Fin=1kHz, Load=8Ω, P_{OUT}=0.2W		0.02	0.1	
Signal-to-noise ratio	SNR	VDD=5V, POUT=1W, Load=8Ω, A weighted noise		96	92	dB
Output voltage noise	V_N	VDD=3.6V, Fin=20Hz to 20kHz, Inputs AC grounded with C_{IN}=1uF	No weighting		50	μV_{RMS}
			A weighting		40	
Efficiency	η	Load=8Ω	VDD=5.5V		91	%
			VDD=3.6V		90	
			VDD=2.5V		89	
		Load=4Ω (Note.1)	VDD=5.5V		86	
			VDD=3.6V		84	
			VDD=2.5V		81	
Thermal Shutdown Temperature	T_{SD}	Inputs ac grounded, A_V=6dB		150		°C

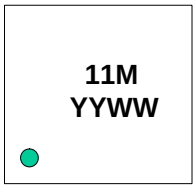
(Note.1) In the case of 4-Ohm load speaker, the package thermal dissipation is not enough. CPA011M is recommended to use higher impedance load speaker if the PCB artwork is not considered thermal dissipation.

Block Diagram



Pin Description





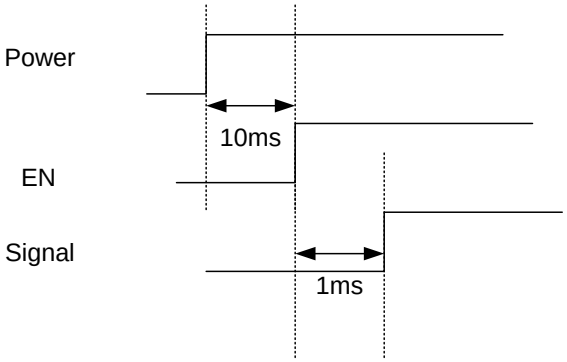
11M: Product Marking

YYWW: Year/Work Week

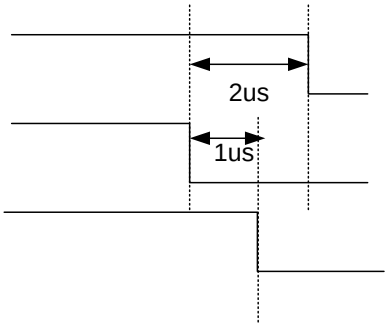
Laser Mark

Name	I/O	PIN	Description
VDD	I	1,5	Power Supply Voltages
VSS	I	7	Power Ground Voltages
IP	I	2	Positive Audio Signal
IM	I	3	Negative Audio Signal
OP	O	8	Positive Output
OM	O	6	Negative Output
EN	I	4	Enable Control Signal(Active High)

Power On/Off Sequence



<Power on sequence>

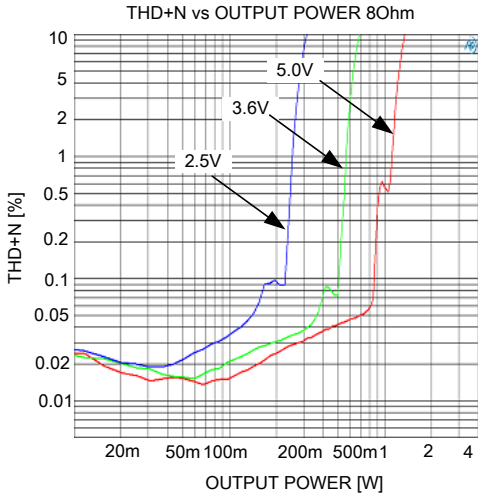


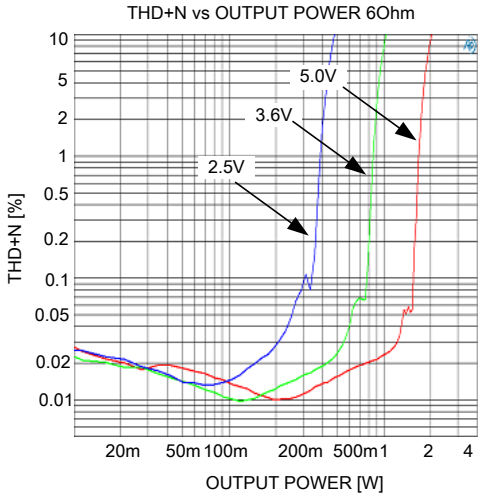
<Power off sequence>

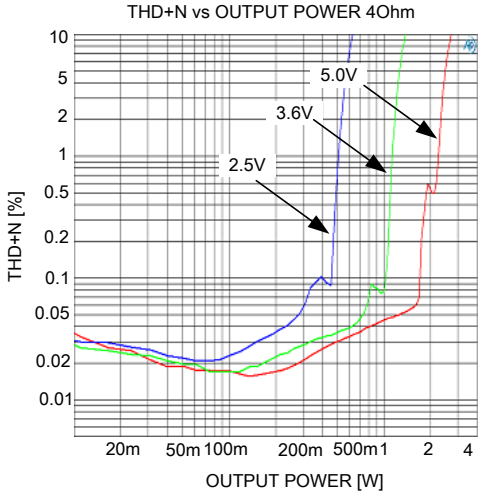
Turn on time of the audio amplifier is not longer than 1ms.

Typical Performance Characteristics

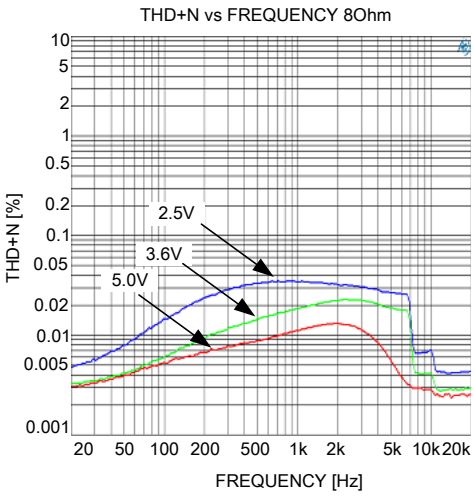
1. THD+N vs. Output Power

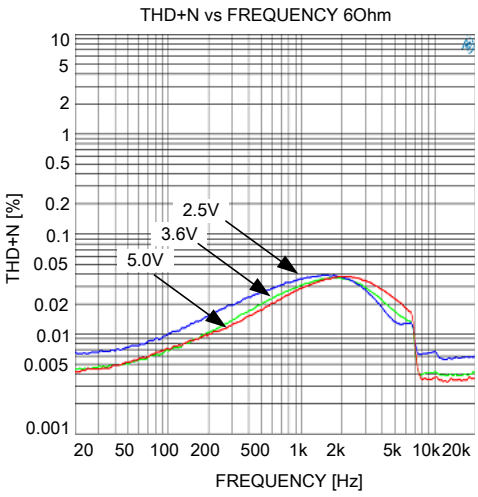


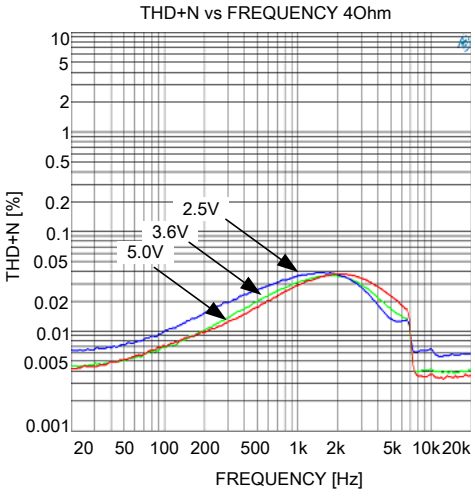




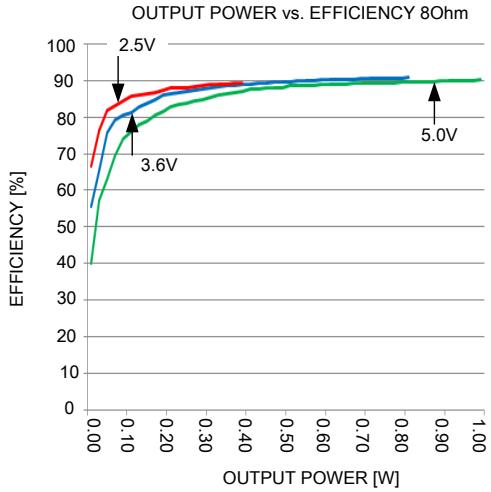
2. THD+N vs. Frequency

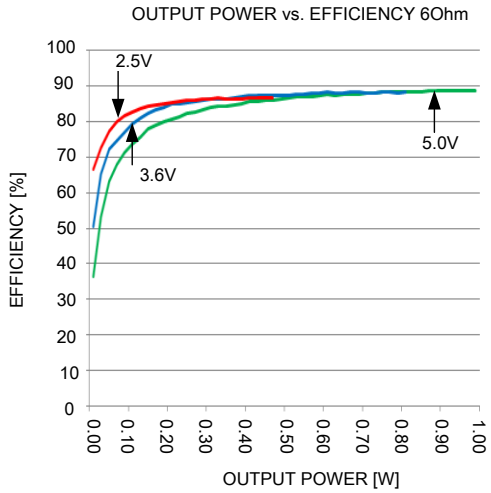


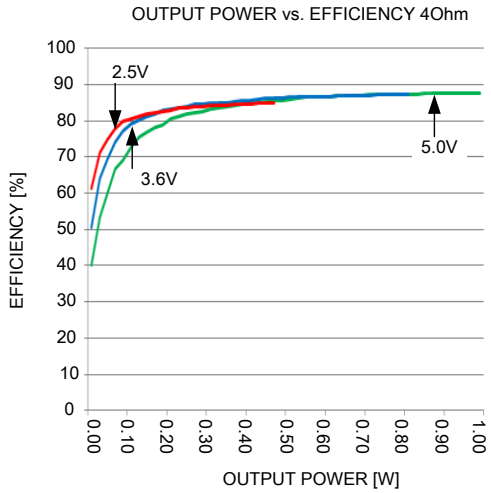




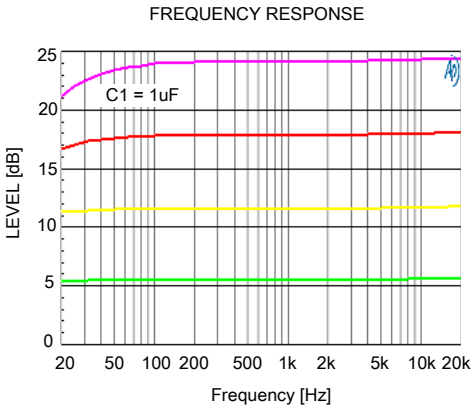
3. Output power vs. Efficiency

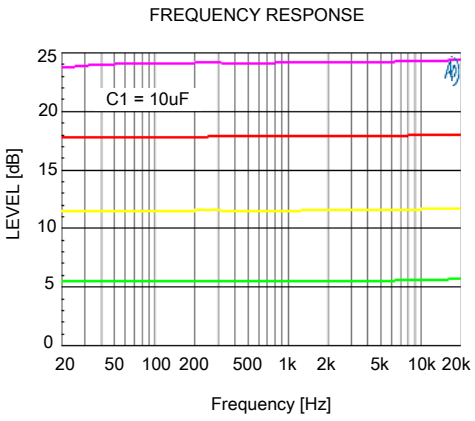






4. Frequency Response





APPICATION INFORMATION

GENERAL AMPLIFIER FUNCTION

The CPA011M is a fully differential input/output amplifier and features a filter-less self oscillation (not using internal oscillator) and spread spectrum modulation scheme. The CPA011M requires input resistors for gain selections. The differential outputs (OP and ON) switch at about 380KHz from VDD to GND. When there is no input signal, the duty cycle of two outputs (OP and ON) is 50% in phase. Two signals cancel each other because of differential output. When there is input signal, the each pulse width of output signals (OP and ON) is changing depending on input signal amplitude. The difference of two output signals yields the differential output voltage.

SPREAD SPECTRUM and SELF-OSCILLATON MODULATION

The CPA011M features a filter-less spread spectrum and self-oscillation modulation scheme that eliminates the need for output filter. The switching frequency varies by -40% below 400KHz frequency depending on input signal amplitude, improving EMI emissions radiated by the speaker, associated cables and traces.

The spread spectrum architecture of CPA011M spreads the energy across larger bandwidth. So switching carrier frequency does not affect the audio reproduction.

And self-oscillation scheme does not require internal oscillation, so CPA011M is effectively circuit designed.

INPUT CIRCUIT CONFIGURATION

Differential Input Configuration

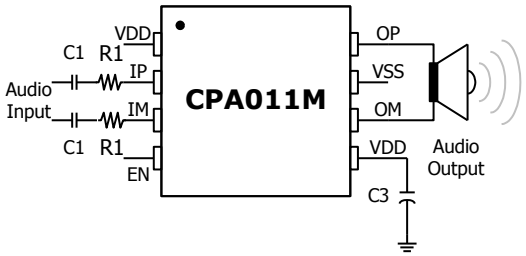


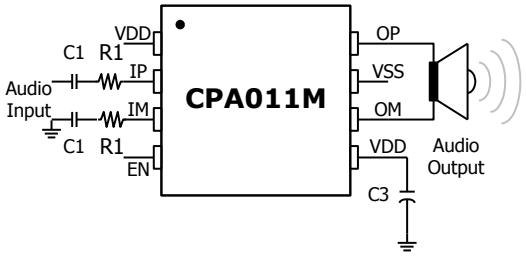
Figure2 shows the normal CPA011M differential input configuration. But if the design uses a differential source that is biased with common- mode input voltage range, input coupling capacitors are not required.

[Fig2. CPA011M Differential Input Config.]

The external resistors must be placed close to IP and IM for gain setting. Default gain Av (R1 =0 Ω) is 24dB (x16).

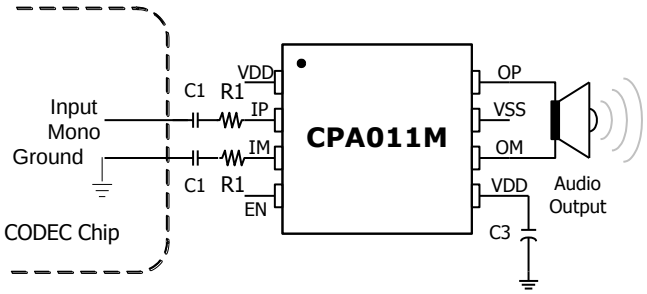
$$A_V = \frac{2 \times 80K\Omega}{(R1 + 10K\Omega)}$$

Single Ended Input Configuration



The CPA011M can be configured as a single-ended amplifier but input capacitors are needed to block any DC at input terminal. The value of input capacitor is important to consider as it directly affects the low frequency performance.

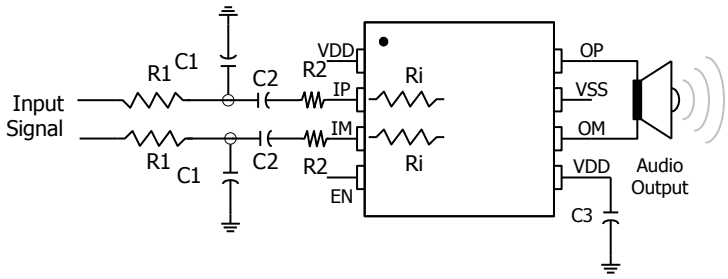
[Fig3. CPA011M Single-Ended Input Config.#1]



To improve audio sound quality at single-ended input configuration, IM(Negative input pin) had better connect with ground of CODEC chip. That is, noise signal of CODEC chip flows to audio amplifier, then the noise signal at CPA011M can be crossly cancelled.

[Fig4. CPA011M Single-Ended Input Config.#2] If IM is separately grounded with CODEC chip, the noise signal of CODEC chip to IP(Positive input pin) can be amplified.

Input Filter Design



Input filter can be sometimes be designed for reducing current consumption and improving sound quality because there are generally the constraints of overall system and the actual frequency band of interest.

[Fig5. CPA011M Filter Design Config.]

Althougn high-fidelity audio reproduction needs a flat gain response between 20Hz and 20KHz, portable devices such as cellular phone need only limited frequency audio band reproduction because of poor frequency response of speaker unit below 150Hz.

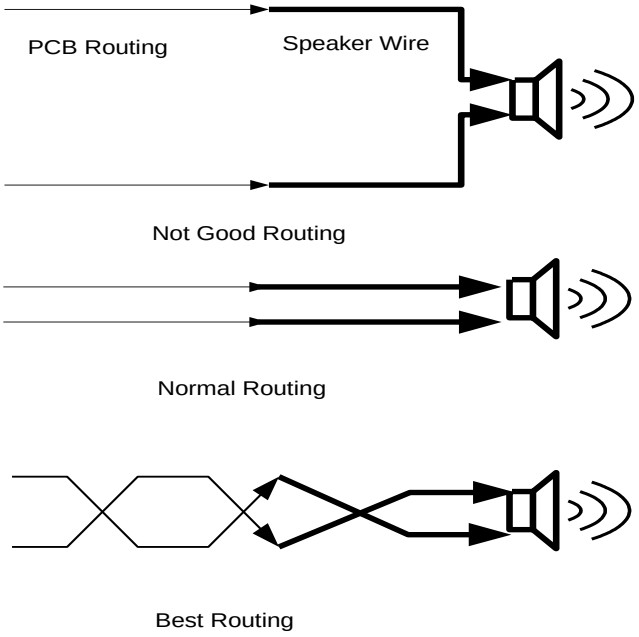
$$f_{LF} \approx \frac{1}{2\pi R1C1} \qquad f_{HF} \approx \frac{1}{2\pi(Ri + R2)C2}$$

The value of Ri is 10KΩ

OUTPUT CIRCUIT CONFIGURATION

Output Line Placement

The CPA011M does not require an output filter (filter-less scheme) and has the high EMI immunity characteristics.

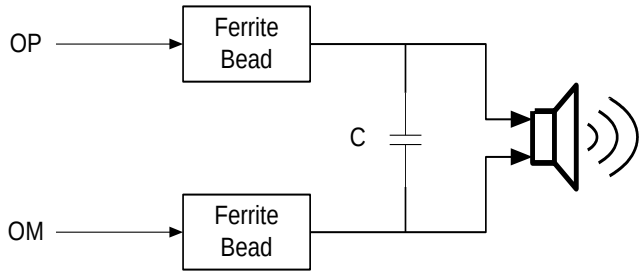


[Fig6. Output Line Description to reduce EMI]

To reduce the EMI, it is important that speaker line is twisted, shielded or closely paralleled.

Output Filter

But if failing radiated emission testing without LC filter, a ferrite bead can be often used in the design. The traces from amplifier to speaker must be usually shorter because the line is functioning like RF antenna.



If choosing a ferrite bead, choose one with high impedance at high frequency, but very low impedance at low frequencies.

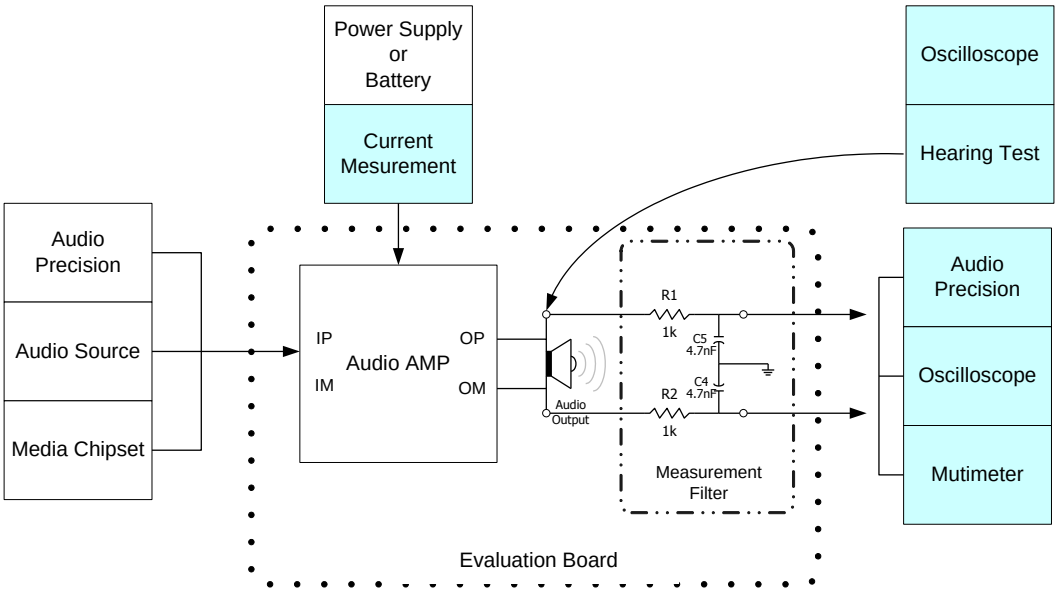
[Fig7. Typical Ferrite Bead Filter]

ANOTHER IMPLEMENTATION CONSIDERATION

The external components like resistor and capacitor must be closely placed to audio amplifier. The traces between amplifier and external components distort the audio input signal and affect the power drop or fluctuation.

The use of power and ground planes will give the best THD+N performance. While reducing trace resistance, the parasitic capacitors between power and ground help to filter power supply line. The output signal line must be considered to be safely separated from another signal line. Sometimes the output line affects badly another chip's signal lines.

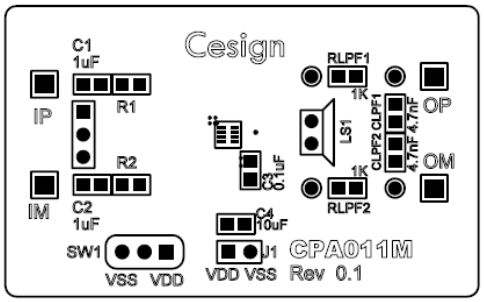
OUTPUT MEASUREMENT ENVIRONMENT



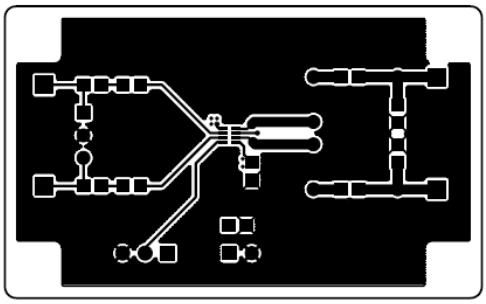
[Fig8. Test Setup Environment]

REFERENCE EVALUATION BOARD LAYOUT and SCHEMATIC

EVM Board component placement and Board Layer



< Top Placement >

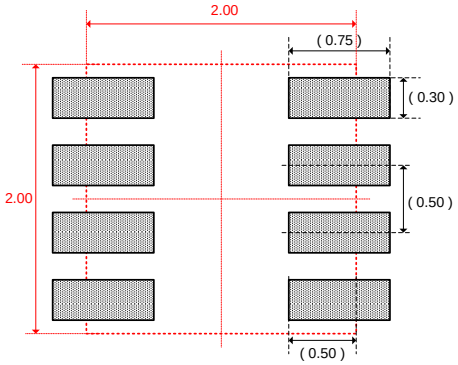


< Top Layer Routing >

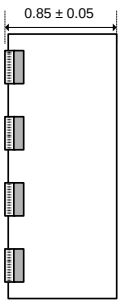
Parts Descriptions

Parts	Parameter	Descriptions
C1/C2	Ceramic 1uF 0603 X7R Top place	Input DC coupling
C3	Ceramic 0.1uF 0603 X7R Top place	Power noise Reduction
C4	Ceramic 10uF 0603 X7R Top place	Power noise reduction
R1/R2	5% Chip Type	Gain Control Resistor
CLPF1/CLPF2	Ceramic 4.7nF 0603 X7R Top place	Measurement filter
RLPF1/RLPF2	Chip 1KΩ 0603 5% Top Place	Measurement filter

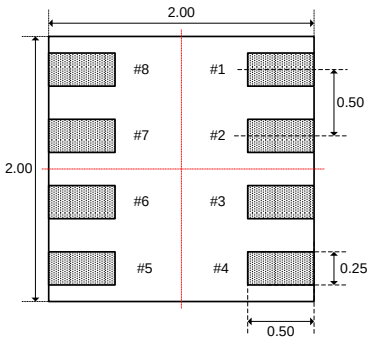
PHYSICAL DIMENSIONS



RECOMMENDED LAND PATTERN

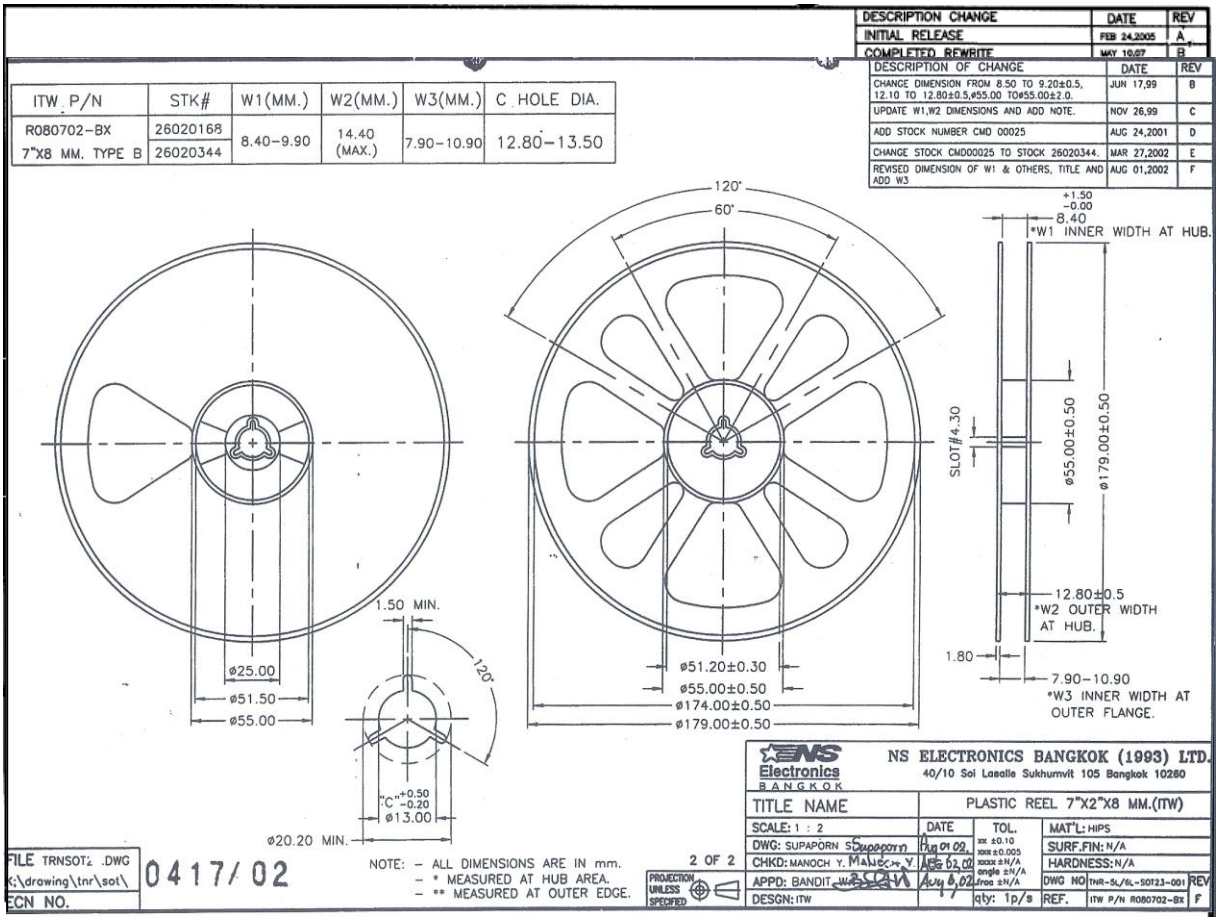


SIDE VIEW



PACKAGE OF OUTLINE

DEMENSIONS are IN MILLIMETERS / DIMENSIONS IN ( ) FOR REFERENCE ONLY


DESCRIPTION CHANGE
INITIAL RELEASE
COMPLETED REWRITE
DATE
REV
ITW P/N
STK#
W1(MM.)
W2(MM.)
W3(MM.)
C HOLE DIA.
R080702-BX
7"X8 MM. TYPE B
26020168
26020344
8.40-9.90
14.40 (MAX.)
7.90-10.90
12.80-13.50
DESCRIPTION OF CHANGE
CHANGE DIMENSION FROM 8.50 TO 9.20±0.5, 12.10 TO 12.80±0.5,ø55.00 TOø55.00±2.0.
UPDATE W1,W2 DIMENSIONS AND ADD NOTE.
ADD STOCK NUMBER CMD 00025
CHANGE STOCK CMD00025 TO STOCK 26020344.
REVISED DIMENSION OF W1 & OTHERS, TITLE AND ADD W3
JUN 17,99
NOV 26,99
AUG 24,2001
MAR 27,2002
AUG 01,2002
120°
60°
+1.50 -0.00 8.40 *W1 INNER WIDTH AT HUB.
SLOT#4.30
ø55.00±0.50
ø179.00±0.50
12.80±0.5 *W2 OUTER WIDTH AT HUB.
1.80
7.90-10.90 *W3 INNER WIDTH AT OUTER FLANGE.
1.50 MIN.
120°
ø25.00
ø51.50
ø55.00
ø51.20±0.30
ø55.00±0.50
ø174.00±0.50
ø179.00±0.50
+0.50 C -0.20 ø13.00
ø20.20 MIN.
NS Electronics BANGKOK
NS ELECTRONICS BANGKOK (1993) LTD.
40/10 Soi Lasalle Sukhumvit 105 Bangkok 10260
TITLE NAME
PLASTIC REEL 7"X2"X8 MM.(ITW)
SCALE: 1 : 2
DWG: SUPAPORN S.
CHKD: MANOCH Y.
APPD: BANDIT
DESGN: ITW
DATE
TOL.
MAT'L: HIPS
SURF.FIN: N/A
HARDNESS: N/A
DWG NO TNR-SL/6L-S0123-001
REF. ITW P/N R080702-BX
qty: 1p/s
FILE TRNSOT2 .DWG
c:\drawing\tnr\sot\
ECN NO.
0417/02
2 OF 2
PROJECTION UNLESS SPECIFIED
NOTE: - ALL DIMENSIONS ARE IN mm.
- * MEASURED AT HUB AREA.
- ** MEASURED AT OUTER EDGE.

Revision Table		
Rev No.	**Date**	**Notes**
Rev0	2007.12	The first preliminary datasheet issued
Rev0.1	2007.12.26	Application note attached
Rev0.2	2008. 2. 4	Page 1. Application Circuit Diagram changed, Page 7. External Component guide added
Rev0.3	2008. 2.26	Page13 "REFERENCE EVALUATION BOARD LAYOUT and SCHEMATIC" is added
Rev0.4	2008. 3. 12	Pin #1 VSS is changed to **VDD** for performance upgrade
Rev0.5	2008. 5. 21	EMI test Result, Making information, Physical Dimensions are added
Rev0.6	2008. 8. 7	$\overline{SD}$ → EN Pin Description changed
Rev0.7	2008. 9. 18	Power On/Off Diagram Added
Rev0.8	2010. 2. 3	THD+N, SNR, Load Condition Changed, Some items added typical value
Rev0.9	2011. 4. 6	THD+N vs Output Power, THD+N vs Frequency, Output Power vs Efficiency, and Frequency Response graph added.